NASA Technical Interchange Meeting (TIM): Advanced Technology Lifecycle Analysis System (ATLAS) Technology Tool Box

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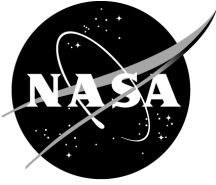
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A&S	Architectures and Systems
ARC	Ames Research Center
ASCT	Advanced Studies Concepts and Tools
ASTP	Advanced Space Technology Program
ASTRA	Advanced Systems Technology Research and Analysis
ATLAS	Advanced Technology Lifecycle Analysis System
CE&R	Concept Exploration and Refinement
CEV	Crew Exploration Vehicle
DD&I	Database Definitions and Interfaces
ESMD	Exploration Systems Mission Directorate
ESR&T	Exploration Systems Research and Technology
EVA	Extra Vehicular Activity
GIGO	Garbage In Garbage Out
GNC	Guidance Navigation and Control
ISHM	Integrated Systems Health Management
IT	Information Technology
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
MEMS	Micro Electro-Mechanical Systems
MSFC	Marshall Space Flight Center
NEXIOM	NASA EXploration Information Ontology Model
SAIC	Science Applications International Corporation
SBA	Simulation Based Acquisition
SISM	Software and Intelligent Systems
TDDC	Technology Data Development and Collection
TIM	Technical Interchange Meeting
TRL	Technology Readiness Level
TTB	Technology Tool Box
V&V	Verification and Validation
WBS	Work Breakdown Structure

CONFERENCE PUBLICATION

**NASA TECHNICAL INTERCHANGE MEETING (TIM): ADVANCED TECHNOLOGY
LIFECYCLE ANALYSIS SYSTEM (ATLAS) TECHNOLOGY TOOL BOX**

On November 8th through 10th, 2004, Marshall Space Flight Center (MSFC) hosted Technical
Interchange Meeting (TIM) in Huntsville, Alabama. The TIM focused on the Technology Tool
Box (TTB), a technology database developed for use by Advanced Technology Lifecycle
Analysis System (ATLAS). ATLAS models use TTB data to model the impact of investing in
different technologies.

The overarching goal of the three-day meeting was to improve the TTB by increasing the
quantity and quality of technical, cost, and programmatic data on different technologies. This
report describes the results of the November meeting, and also provides background information
on ATLAS and the TTB.

1. INTRODUCTION TO ATLAS AND THE TECHNOLOGY TOOL BOX

Currently under development, ATLAS provides a capability to evaluate technology portfolios
that support future space exploration. Control software within ATLAS manages a collection of
Excel workbooks, each describing an element within an overall space exploration architecture.
Within the context of ATLAS, a collection of space transportation systems, supporting
infrastructure, and scientific payloads constitutes a space architecture. An analyst can assemble
a complete space architecture by combining modeled elements and specifying parameters and
technologies to be employed in those elements. For the given set of parameters and
technologies, the analyst can display system performance parameters such as mass and cost.
Thus, ATLAS provides strategic planners with a decision support tool to evaluate potential
technology portfolios.

ATLAS models rely on data about the different technologies drawn from the TTB. The TTB
contains technology data from within NASA as well as data gathered from outside sources.

Presently, the TTB exists as an Excel workbook but work has begun on a web-accessible
version. On the first day of the TIM, Daniel O'Neil and Lamonte Dent demonstrated the
prototype web version of the TTB depicted in Figure 1.

The record for each technology includes approximately two dozen performance metrics (such as
mass and power required), operational metrics (such as operational lifetime and mean time
between failures) and programmatic metrics (such as technology readiness level, index value
reflecting development risk, and development timelines). Furthermore, the TTB also contains
projected future values of these metrics. These projected technology metrics allow ATLAS to be
used as a tool to rapidly evaluate and compare the potential cost and performance benefits over
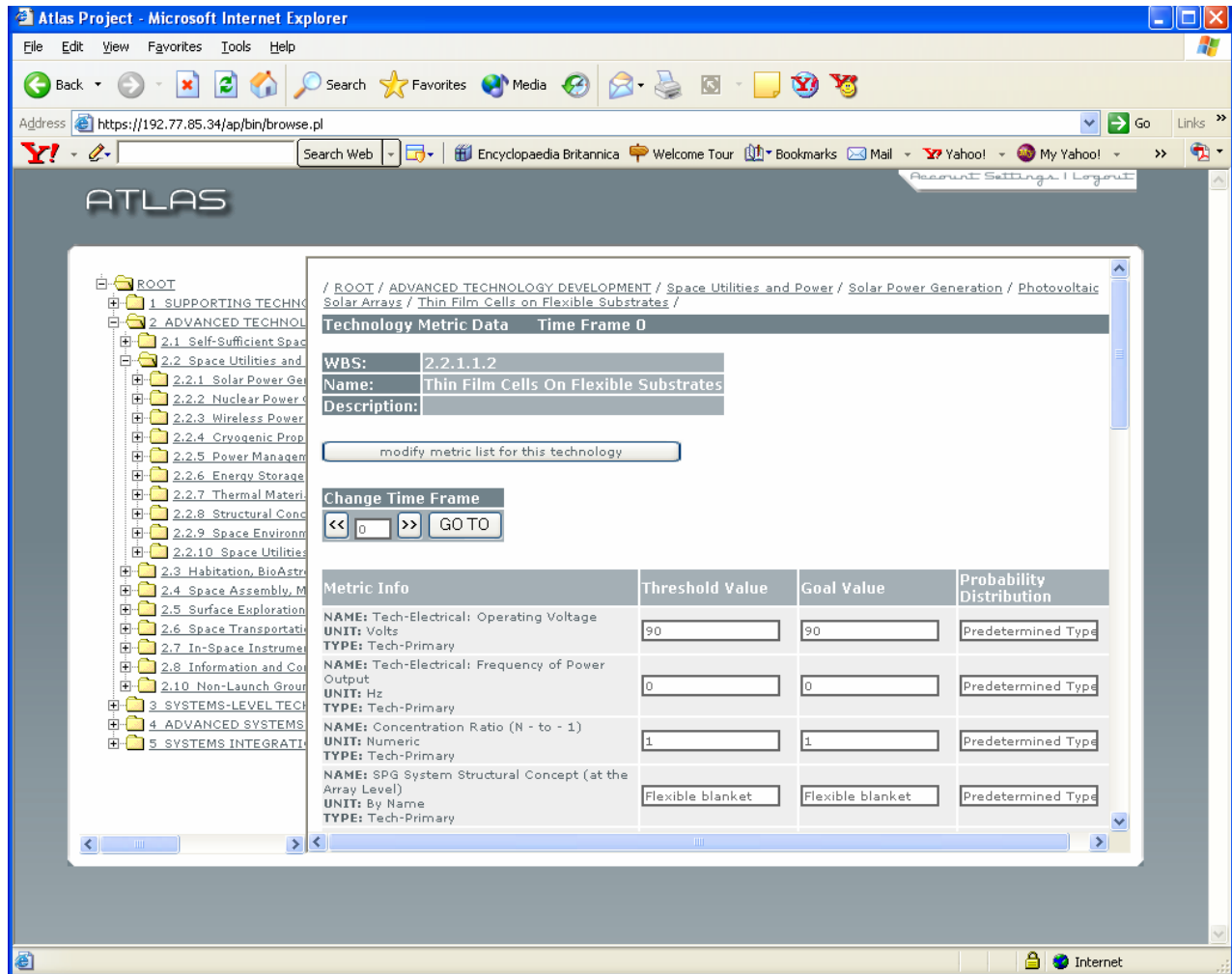time of various technology investment scenarios.

Figure 1 A web-accessible Technology Toolbox (TTB), which will allow for easy updating and additions, is under development. This figure illustrates an example of the user interface for the TTB.

2. MEETING OVERVIEW AND OBJECTIVES

The overarching goal of the three-day meeting was to improve the TTB by increasing the quantity and quality of technical, cost, and programmatic data on different technologies. To this end, TIM participants were asked to provide specific data and comment on data provided by others; to discuss underlying definitional and interface issues with regard to the technology tool box and related tools, and to address architecture and system issues for the TTB, ATLAS, and the related Simulation Based Acquisition (SBA) system currently under development by NASA Exploration Systems Mission Directorate (ESMD).

The objectives of the TIM were outlined in a plenary session on the first day and addressed in detail in breakout working groups on the second day. The results, accomplishments, and achievements of the working groups were briefed and discussed at a plenary session on the third, and final, day of the meeting.

2.1 Opening Plenary Session

ATLAS and its components (such as the TTB) are part of the Exploration Systems Research and Technology (ESR&T) Program of the NASA Headquarters Exploration Systems Mission Directorate (ESMD) at NASA Headquarters.

ESR&T/ESMD has a dedicated element focusing on analytic studies and tools for advanced exploration concepts. Doug Craig, the Program Element Manager for this activity (Advanced Studies Concepts and Tools, or ASCT), kicked off the TIM during Monday's plenary with a perspective from NASA Headquarters. He presented an overview of the ESR&T Program and ASCT within it, providing guidance and background for the discussions that followed over the next two days in each of the working groups.
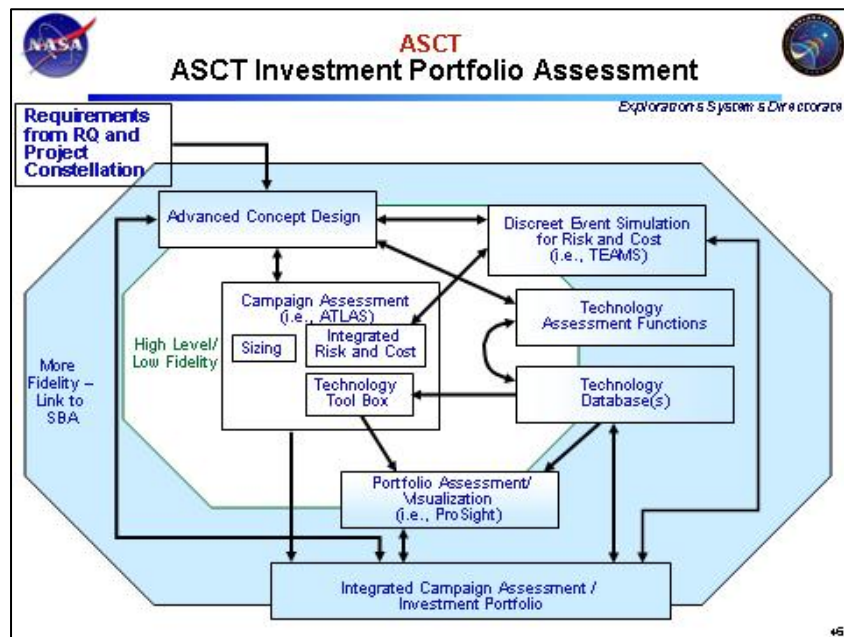
Mr. Craig described the ASCT investment portfolio assessment process and the context for ATLAS and the TTB (depicted in Figure 2).

Figure 2 Doug Craig introduced the participants to ASCT and defined ATLAS and the TTB's role within ASCT and ESR&T

In this process, Advanced Concept Design activities generate requirements for ATLAS workbook system models. Analysts use ATLAS to configure systems and select technologies to meet mission campaign objectives. Other tools for detailed risk assessment will use the system configurations, technology portfolios, and technology data provided by ATLAS and the TTB. Other technology databases will provide narrative descriptions, pictures, and technology development history. Links to a common Work Breakdown Structure (WBS) and other key data fields will provide a capability to correlate records among the TTB and other technology databases.

2.2 Working Groups

The hands-on work of the TIM was conducted through breakout working groups on day two. The diverse participant list of the TIM allowed for an open dialogue and a sharing of ideas for the database between industry and NASA personnel. Participants represented the following teams and organizations:

- Winning Exploration Systems Research and Technology (ESR&T) Intramural Call for Proposals (ICP) teams,
- Contractors from Exploration Systems Mission Directorate (ESMD) Capabilities Office Concept Exploration and Refinement (CE&R) teams,
- The Advanced Studies Concepts and Tools (ASCT) Leadership team,
- The SBA development team,
- Local contractors researching historical data for the TTB,
- The Future Concepts Office within the MSFC Space Systems Programs & Projects Office, and
- The ATLAS project team, including The Tauri Group, which facilitated data collection and working group reports in addition to participating in technical discussions.

Each of the forty-two technology experts participating in the TIM was assigned to one of three groups: Technology Data Development and Collection; Architectures and Systems; and, Database Definitions and Interfaces. The groups conducted detailed discussions and addressed specific technical goals.

The Technology Data Development and Collection (TDDC) working group (chaired by Monica Doyle and Jamie Esper) The group was charged to review and come to consensus on technology data provided by participants. The group was also asked to expand on and document the data, by defining growth scenarios for selected data sets and developing a completion plan for marginal data sets, with likely assignments of individuals to provide certain data.

The Architectures and Systems (A&S) working group (chaired by Harvey Feingold and Carissa Christensen) was charged to define what is needed for successful ATLAS modeling and analysis. The group was directed to discuss ATLAS existing and planned models. The discussion encompassed the technology data the models currently use, additional types of data they should use in future versions, and the interplay and relationship of ATLAS models to the TTB and the SBA. Based on these discussions, the group was asked to identify strategies for integrated use of TTB.

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The Database Definitions and Interfaces (DD&I) working group (chaired by Doug Craig) was charged to develop an analysis plan for ESR&T, assessing the possibility for other tools used by ESR&T to employ the TTB and/or ATLAS. The group's activities constituted important pre-planning for a future tools workshop to be hosted by Ames Research Center (ARC).

3. MEETING FINDINGS AND ACCOMPLISHMENTS

The findings and accomplishments of each of the three working groups are summarized below. Each of the groups developed a briefing package that reported out its discussion and recommendations. Appendix B contains the complete out-briefs from the working groups.

3.1 Technology Data Development and Collection (TDDC) Working Group

The TDDC working group addressed key technology data issues in its breakout session on day two. Jaime Esper and Monica Doyle led the discussion among 20 participants in the TDDC working group. This working group successfully collected 27 data sets in 16 areas of the Advanced Systems Technology Research and Analysis (ASTRA) work breakdown structure (WBS). The group specifically discussed in detail WBS elements 2.2.1 Space Solar Power and 2.6.1 Earth-to-orbit transportation during the breakout session. Figure 3 identifies the number of data sets collected in each of these areas at the three-digit WBS level.

The TDDC working group also formulated recommendations for improving the data collection process, refining definitions of data fields within the TTB, and defining operating assumptions to provide a context for technology data.

> **TDDC Findings and Accomplishments**
>
> ✓ Collected 27 sets of data in 16 technology areas
> ✓ Developed strategy for handling contradictory data submissions
> ✓ Outlined processes to improve data collection efforts
> ✓ Discussed export control and proprietary data issues
> ✓ Improved definition and understanding of goal and threshold values
> ✓ Identified potential for technology maturation paths

Participants discussing specific technologies in the TDDC Working Group

The working group addressed the challenging question of how the TTB should handle different types of sensitive data, specifically company-proprietary data and data that might be subject to export controls.

In considering whether the TTB could omit proprietary data to avoid data protection problems, participants concluded that the utility of the TTB requires competing companies to share data. Participants reported that their companies were most concerned about sharing budget forecasts required to achieve certain performance levels in a specific timeframe; they said that budget projections were more sensitive than forecasts of performance and operations metrics. Participants also generally agreed that it would be helpful to avoid specifically identifying a company as a source of data, to ensure data integrity.

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Industry participants also raised concern about export control restrictions, because the aggregation of data from many sources in the database might result in its being subject to export controls, while specific data provided by an individual contributor was not. From a security perspective, the whole of the database could be greater than the sum of its parts. An unauthorized release of a single record may not be a problem; however, the release of the entire database would a problem. Individual data contributors were concerned about their ability to follow export control procedures if they contributed data when they did not have control over the whole database. The group formulated recommendations for handling these issues by controlling access at the database, record, and field levels. It was also generally agreed if this process were followed it would be easier to collect data.

Other discussions involved the definitions of several important and complex metrics: technology performance goals, threshold values, and technology readiness level (TRL) forecasts. The terms "goal" and "threshold", to describe Technology Development progress, were considered difficult to define precisely by many of the participants. One suggestion for defining these terms was to replace these parameters or categories with mean and deviation. (In the near term, technologist could assume a normal probability distribution. Later versions of the TTB could offer a selection of pro-bability distributions as a drop-down menu field.) The group also sought additional precision in estimates of technology readiness level. Several technologists stated that a TRL path indicating the relative focus on tech-nology maturation versus pure research should be specified before fore-casting performance and operations metrics. (In a technology maturation path, the TRL increases while the performance values remain constant. In a pure research path, the performance increases while the TRL remains constant.) It was noted that this could add structure to the data collection efforts.
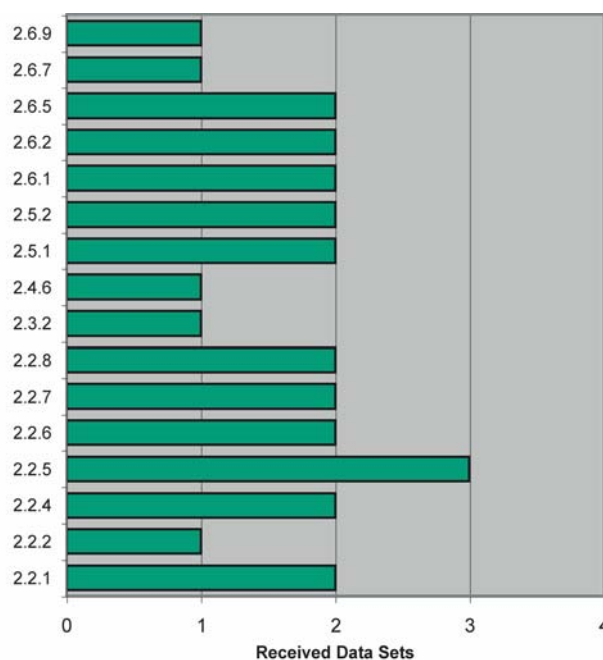

Figure 3 Number of data sets received in technology areas

Finally, the group raised the question of whether ESMD could characterize its future development spirals in a manner that indicated where a certain level of technology maturity (typically TRL 6, at which the technology has been demonstrated) would be needed.

3.2 Architectures and Systems (A&S) Working Group

The A&S working group addressed a range of issues including: modeling and analysis needs in ATLAS and the TTB; planned models and architectures to be used with the TTB, ATLAS, and SBA; and technical data requirements driven from the architectures and system needs. Harvey Feingold and Carissa Christensen led discussions among the fifteen participants in the working group, which came to findings related to context, the user community, system functions, and optimization.

The context, primary functions, and uses/users for ATLAS were discussed to provide a shared understanding of the current system. ATLAS, it was agreed, provides a quick-look capability to figure out what makes sense. With ATLAS, a strategic planner can compare technologies, conduct top-level architectural trade studies, and plot "living forecasts" from the TTB. ATLAS is not to be considered as or

> **A&S Findings and Accomplishments**
>
> ✓ Clarified the context for ATLAS
> ✓ Identified the user community for ATLAS and the TTB
> ✓ Outlined system functions
> ✓ Discussed optimization functions

used as an engineering design tool. The functions of ATLAS can be grouped into: technology payoff calculations and a tool to compare technology, mission, and campaign strategies. Presently, the ATLAS user community consists management and designated representatives of the ESR&T program office.

The group considered what user groups should be targeted as ATLAS moves forward. Potential users identified included: NASA Headquarters program managers, strategic planners, program planners, engineers, technologists, and perhaps students as a teaching tool. The group noted that ATLAS models require a full understanding of the capabilities and limitations of the models; both technologists and system model developers were concerned about the possibility of garbage in/garbage out. In fact, the consensus of the A&S working group was that the TTB (rather than specific models) might be the most useful part of ATLAS for a broad base of users.

The A&S working group addressing big-picture ATLAS and TTB issues

The working group reviewed plans for optimization functions in ATLAS; the team noted that the ATLAS proposal for future activities includes this function as part of the later development. The team recommended that figures of merit to use as goals for optimization include cost, mass, and safety or risk and that items to vary in the optimization function include technology, systems, and architectures.

Several participants in the A&S working group asked, "What is the relationship between ATLAS and the Simulation Based Acquisition (SBA) project?" which led to further discussion. Doug Craig addressed this question by explaining that both systems will work towards a common data dictionary or ontology, the SBA supports the strategy-to-task activity, and SBA will support a more detailed level of analysis than ATLAS. The two projects will share tools and develop compatible data file formats. For example, the SBA will develop risk analysis tools at the technology and system level. The ATLAS could provide data to or receive data from these risk analysis tools.

3.3 Database Definitions and Interfaces (DD&I) Working Group

Doug Craig and Daniel O'Neil led a discussion among nine participants in the DD&I working group. Accomplishments included: planning for convergence of the ATLAS and SBA technology databases, pre-planning for the future tools workshop, planning architecture development and campaign analysis activities, and defining terms used across ASCT.

During pre-planning for the tools workshops working group members were assigned actions to document the process and products associated with ASCT activities Advanced Concepts, Technology Databases, Campaign Analysis, Risk Analysis, and Data Visualization. These plans will identify potential opportunities for integration of SBA and ASCT tools. Most of the group's participants were tasked with documenting process and products in preparation for the tools workshop.

DD&I Findings and Accomplishments
✓ Planned for convergence of ATLAS and SBA databases
✓ Pre-planning for future tools workshop
✓ Outlined architecture development and campaign analysis activities
✓ Defined several cross-cutting ASCT terms

Discussions on architecture development and campaign analysis activities addressed the diagram in Figure 2. In Figure 2, the box in the upper left corner identifies incoming requirements from the ESMD Requirements Directorate and Project Constellation. These requirements will include a Point-of-Departure architecture. The Advanced Concept Design team will analyze the requirements and develop alternative architectures with system concepts that emphasize technologies under development by ESR&T. To assemble these architectures within ATLAS, the Advanced Concept Design and ATLAS teams will work together to create Excel workbook models. A campaign assessment team will use ATLAS to evaluate the impact of technologies to the lifecycle costs of the architectures.

The working group specifically discussed several terms that are used throughout ASCT, and came to agreement on clear definitions. The terms defined by the DD&I working group were:
- Architecture, a collection of systems that provide the capability to perform one or more types of missions.
- Campaign analysis, evaluating benefits across a sequence of missions and systems. This analysis involves determination of architecture sensitivities to technology portfolios. Campaign analysis will support the ASCT Advanced Study teams, answer action items received by the ESR&T program office, and serve as an integral part of the annual technology assessment and investment process. Through campaign analysis, the ASCT will verify and validate technology data.
- Point-of-departure architecture, a reference for benefit assessments produced by NASA and the Concept Exploration and Refinements Teams.
- Ontology, the organizational structure of the campaign, architecture, systems, and technology data.
- Threshold value, the minimum achievable value within a range of technology parameters.

The DD&I working group also discussed and came to agreement on an analysis plan for ATLAS and the TTB. Steps in the plan include: defining data requirements, developing a centralized repository of technology data, determining a data migration path, and decide on a risk analysis tool. Specifically the team decided that a data verification and validation team within ASCT will define the requirements for the TTB data collection. These requirements will define the data pedigree within the database. The centralized repository of technology data would provide controlled access to the technology records, while allowing record owners to provide the pedigree of data values.

DD&I working group participants plan the future of the TTB and other technology databases

The repository should also: be controlled to comply with export control restrictions, include data to support technology and system level risk analysis, associate a degree of confidence or uncertainty with each piece of data, and be able to export a subset of the data for use in other applications. The data migration path begins with ATLAS and the TTB initiated in Excel and MySQL. The next step is the production of the SBA information model. The follow-on to these activities will be in the form of experiments evaluating the capability to transfer data between MySQL and the SBA database management system.

4. RECOMMENDATIONS

Each working group developed recommendations based on its findings. These recommendations are summarized below. The full outbrief from each working group can be found in Appendix B.

4.1 Technology Data Development and Collection Working Group

The Technology Data Development and Collection Working Group (TDDC WG) technologists recommended a number of changes or enhancements to the TTB. (Figure 4 depicts the current layout of the TTB.)

The group grappled with the problem of defining performance and operations metrics for a technology without knowing the specific application for the technology. Some components may have the same metrics regardless of the surrounding system, but many subsystem performance and operating metrics will depend on the system. To address this issue, the working group recommended that the TTB include ground rules and assumptions at the three-digit WBS level. This would provide a general description of potential applications to technologist and technology selection guidance for the system modelers. The working group also recommended that a process be developed for dealing with conflicting data areas, and that these data sets need to be examined and then judged to be unique from one another or truly conflicting data. It was recommended that for the near term judgment should err on side of allowing each conflicting data set to become a unique data record. Once teams have been assigned to a given technology, individual data records can be better reconciled to condense redundant data sets.

The group addressed the fundamental question of how to efficiently use technologists' time to collect data, given the more than one hundred thousand data points the TTB is ultimately slated to contain. The consensus was the data collection process should involve a core membership yet invite new participants to ensure fresh data. The group discussed how to identify the right individuals to participate in the process and identified several interdisciplinary or inter-organizational strategies. For example, the group suggested including members crosscutting technology development teams within NASA in the data collection process. The group also noted that if the core membership of the data collection team included both NASA and industry members, data verification and definitional issues would be easier to overcome. Finally, the TDDC group recommended that the future process discussions involve both users and developers of ATLAS models so that architecture and model perspectives could be added to specific decisions regarding data collection techniques.

2.2.1_Solar Power Generation							STATUS	Template, Metrics & prelim data	TIME FRAME 0			TIME FRAME 1		
WBS	THEME	Technology Element	TECHNOLOGY Sub-Element	NAME TECH OPTION	METRIC NAME	METRIC UNITS	Metric Type	METRIC VALUE (Threshold)	METRIC VALUE (Goal)	METRIC Probability Distribution	METRIC VALUE (Threshold)	METRIC VALUE (Goal)	METRIC Probability Distribution
2.2.1.1.1	Space Utilities and Power	Solar Power Generation	PV Solar Arrays	Single Crystal MBG	Energy Conversion Type	By Name	Tech-Primary	PV Conversion	PV Conversion	Predetermined Type - PBD	PV Conversion	PV Conversion	Predetermined Type - TBD
2.2.1.1.1	Space Utilities and Power	Solar Power Generation	PV Solar Arrays	Single Crystal MBG	Efficiency @ "Cell-Level" (at 1 AU)	%	Tech-Primary						Predetermined Type - TBD
						W / kg	Tech-Primary						Predetermined Type - TBD
						%	Tech-Primary				Type - TBD		Predetermined Type - TBD
2.2.1.1.1	Space Utilities and Power	Solar Power Generation	PV Solar Arrays	Single Crystal MBG	Array Degradation per Year	%	Tech-Primary			Predetermined Type - TBD			Predetermined Type - TBD
2.2.1.1.1	Space Utilities and Power	Solar Power Generation	PV Solar Arrays	Single Crystal MBG	Operating Temperature	Degree C	Tech-Primary			Predetermined Type - TBD			Predetermined Type - TBD
						Hours	Operations-P			Predetermined Type - TBD			Predetermined Type - TBD
					(MTBF)	Hours	Operations-P			Predetermined Type - TBD			Predetermined Type - TBD
	Space	Solar		Single	Current Technology	TRL (1-9)	Tech R&D-P			Predetermined Type - TBD			Predetermined Type - TBD
	and Power	Generation		MBG	(Average)	R&D3 (1-5)	Tech R&D-P			Predetermined Type - TBD			Predetermined Type - TBD

Callout boxes within the figure:

> Performance metrics differ among technologies. Technologists identify performance for use by system engineers in parametric sizing equations. Metrics should include mass, area, power, energy density, etc.

> Columns represent 12 timeframes starting in 2005 and extending 33 years in 3 year increments. Technologists estimate the improvement in performance and operations and the funding required to mature the technology.

> Operations data includes metrics for sizing workforce, facilities and processing timelines.

> Programmatic metrics are standardized across all technologies. These metrics include TRL, R&D[3] and TNV.

Figure 4 An example of a record with data and format descriptions as it would appear in the TTB

4.2 Architectures and Systems Working Group

Recommendations from the Architectures and Systems Working Group (A&S WG) for future ATLAS and TTB activities addressed model development, documentation, maintenance, management, and validation, and workshop processes. The group discussed current models within the ATLAS library, which include parametric sizing equations related to propulsion, solar power generation, power management and distribution, and in-space energy storage. These technologies were used because the system model developers considered these technologies to be relevant to sizing the system and data was available in the TTB; in addition, many of these models were relatively small development activities. As a result, some models may not include important parameters. For example, models in the current version of the ATLAS library do not use material properties, which significantly affect system mass. The group recommended that as ATLAS development activities increase, models be reviewed and, if needed, revised to ensure that they include parameters for the most significant technologies and that new models being developed incorporate these parameters.

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Significant technology areas for future models (and by extension, the TTB) included information technology, cross-cutting technologies, and software technology that affects operations. Each is discussed below.

System and infrastructure models should emphasize the impact of information technology (IT). For example, technologies associated with the TTB Work Breakdown Structure (WBS) 2.5.1 "Mobile Surface Systems" and 2.5.2 "Subsurface Access" should include IT. Experts at Ames Research Center (ARC), Jet Propulsion Laboratory (JPL) and Johnson Space Center (JSC) could provide technology data and suggesting additional metrics. Life cycle and mission phases that benefit from IT include development, operations and flight crew time. Costs for IT has become a significant percentage of the development phase for aeronautic and space systems. Through improved IT, operations costs for future exploration systems could be lower than the Space Shuttle and Space Station. A major goal of the exploration initiative is to make the flight crew less dependent on the ground. Subsystems that require human attention (such as propulsion, guidance navigation and control, life support, extra vehicular activity, and others) take astronaut time away from science and exploration; consequently, flight crew time requirements will figure prominently in trades concerning onboard systems.

Cross-cutting technologies are not as well represented in the current database as they could be. These include technologies such as integrated system health management and software verification and validation, which could decrease failure rates, cost overruns, and maintenance costs across many systems. Other cross-cutting technologies include fundamental hardware advances, such as novel chip technology, micro electro-mechanical systems, and nanotechnology, which could have implication in sensing, mass, and reliability across many systems.

Future system models should include parametric equations for technologies that affect reliability, safety, and cost. These include software affecting operations such as: planners and schedulers, system health management software, autonomous systems, training and simulation tools, and data analysis and management software. Many of these software technologies reduce the size of the ground system workforces and increase the time available for a flight crew to conduct science and exploration, thereby increasing mission efficiencies. Other safety, reliability, and cost recommendations were that transportation system models include abort and return-to-Earth capabilities, and also, that system models include technology options that affect maintainability and human factors. Finally, the group noted that defining the cost estimating relationships for "ilities" is an interdisciplinary process that must involve the technologists that define the performance and operations metrics of specific components or subsystems, the domain "ility" expert, the system modeler, and the cost analyst.

The working group also identified other desirable model features (in addition to the inclusion of particular technologies or types of technology. The group recommended a report that summarizes user inputs; automated notification of TTB updates; and a flag to indicate a user-defined technology. The team recommended that the ATLAS project produce development roadmaps that identify model content and number of users, and provide web-based presentations to new users; that future TTB developments include fields for data entry dates and sources; and that additional TTB fields for assessment of quality or confidence in the data be added.

The A&S working group recommended that the documentation developed with the ATLAS prototype include: requirements, a detailed design document, a user's guide, a model developer guide, a test plan, and a system model compendium. The group recommended that each system model include documentation worksheets such as an introduction, model information, and a change log. Future versions of ATLAS system models should be required to include documentation of the algorithms, descriptions of technology parameters used by the models, and information worksheets to explain case studies and their assumptions about the space exploration architecture.
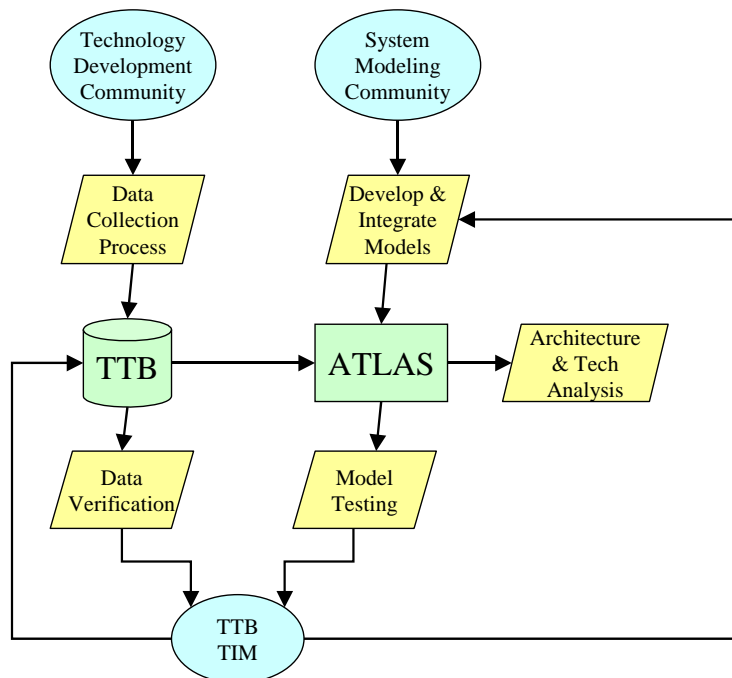
Figure 5 A notional process for data collection and model integration

The working group identified maintenance, configuration control, and validation as potential issues for ATLAS system models. One specific insight was that maintaining system models and data within the TTB may require on-going support contracts that can provide training, trouble-shooting, update documentation, and facilitate the integration process for new models and data. The working group recommended implementing configuration control and validation processes. The validation process could involve modeling a known architecture and mission campaign, for example, Apollo. Cost analysis could compare results from ATLAS with historical data to verify the system and validate the models and data.

Comparisons between results from ATLAS and SBA or other analytical tools could support a validation process. After passing a verification and validation process, a control board could stamp the system model with a logo that indicates approval. Figure 5 depicts a notional process for collecting and verifying data in conjunction with developing and integrating models that use the data. On the left side of Figure 5, the ATLAS team works with representatives to collect data from the technology development community and enter the data into the TTB. In parallel, the system modeling community produces Excel workbooks that the ATLAS development team integrates into ATLAS. Using data from the TTB, the ATLAS team tests the models and presents the results at a TTB TIM. Concurrently, the TTB team conducts a data verification process with the technologists and presents the results at the same TTB TIM. As the technologists and systems engineers review the results of the ATLAS model testing, they should reach a consensus on the validity of the data and models. Recommendations from the TIMs feed back into the TTB and improve the data collection and verification processes.

Finally, the group suggested that briefing the results of previous relevant TIMs at the opening of each new TIM, sharing the details of the ATLAS development process and project plan with those working on ATLAS related activities, and developing tools to enable on-going

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communications with the communities of interest in ATLAS and the TTB. Existing studies and study efforts that could benefit the development of ATLAS system and operations models. Examples given were: a FY 2003 study by the Intelligent Systems program of the impact of different classes of information technology on the effectiveness of Mars Rover missions; an in-progress ASTP study on autonomy for NASA Crew Exploration Vehicle (CEV) operations is producing rough estimates of how stations and shuttle operations costs decompose by major system, and rough estimates of the development costs for automation; and, an ongoing activity with funded by the Software and Intelligent Systems Modeling program evaluating the impact of some classes of integrated systems health management technology on CEV operations.

4.3 Database Definitions and Interfaces Working Group

The DD&I working group recommended that ASCT establish a verification and validation team to define requirements for the TTB data collection process. As for technology database development, the group recommended that ATLAS project continue with the development of Excel and MySQL versions of the TTB, while a concurrent systems-based acquisition effort develops an information model that incorporates the TTB ontology. The working group also recommended that the ATLAS team adopt a risk analysis tool instead of developing one as a part of ATLAS.
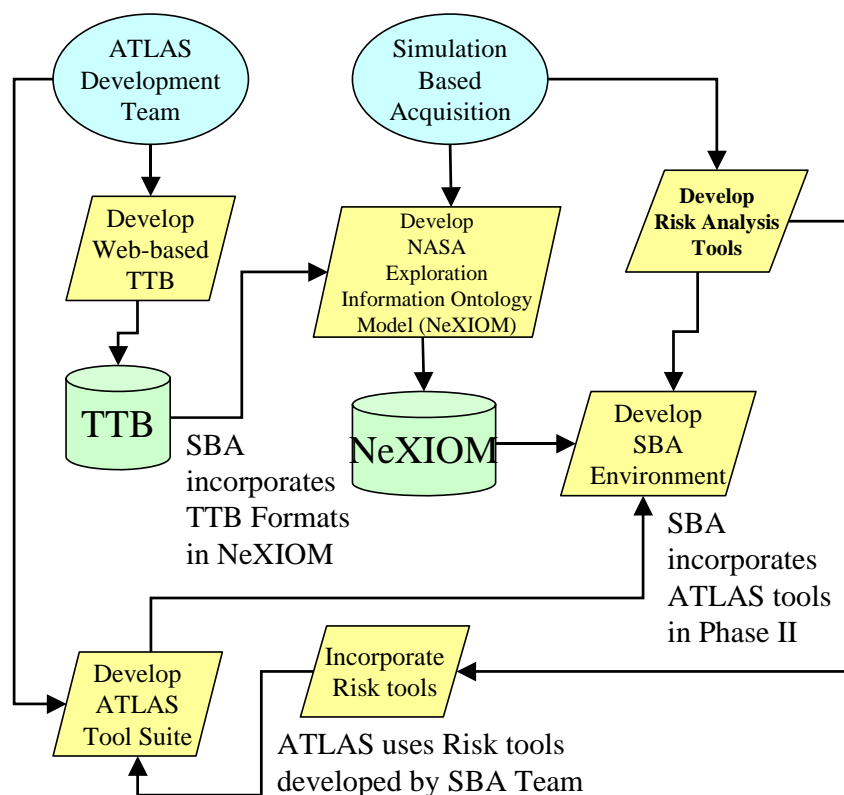

Figure 6 Relationships between ATLAS and SBA

The group recommended improving technology data collection by placing data requirements in the statements of work of contracts awarded by the ESR&T programs. The group suggested that data requirements identify the TTB data format and indicate that the termination review process for each contract year will require evidence that the contractor provided technology data in that format. The group also urged that formats of the technology roadmaps be consistent between the ATLAS TTB and campaign analysis data requirements.

Figure 6 depicts the working relationships between the Simulation Based Acquisition (SBA) development team and the ATLAS development team. During 2005, the ATLAS team will continue development of a web-based version of the TTB while the SBA develops the NASA Exploration Information Ontology Model (NeXIOM). The SBA team will incorporate the data

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formats from the TTB into NeXIOM. The plan discussed by the group calls for experiments conducted in May 2005 that will evaluate the capability to transfer data between the two databases. A successful demonstration of NeXIOM will motivate a migration of data from the TTB to NeXIOM. Risk analysis constitutes another area where the ATLAS and SBA teams can work together. Figure 6 illustrates how the SBA team will develop risk analysis tools and the ATLAS team will include the tools in the ATLAS tool suite. In Phase II of ATLAS development, the SBA team can incorporate the ATLAS tool suite into the SBA environment.

4.4 Recommendations from Plenary Session Discussions

The meeting concluded on day three with a plenary session. Working group leaders briefed each group's accomplishments and recommendations. In addition, an open discussion among the meeting attendees identified potential improvements to the data collection and workshop process. Finally, Doug Craig closed the meeting with remarks that provided an overview from the perspective from NASA Headquarters.

Several recommendations were made in the general discussion, particularly regarding future workshops. As the ATLAS team takes the next steps it was recommended that workshops be used as a forum for reporting on progress and addressing crosscutting issues. Specific recommendations for future workshops included: dedicating a day for mapping technologies to system models; using the first day of the workshop for model developers to present an overview of their models and technologists to present an overview of the technologies; and, using the second day to bring technologists and model developers together to identify parametric sizing equations and data requirements. It was also recommended that pre-workshop data collection activities involve web-based application sharing programs where teams could view the ATLAS models and contents of the TTB from a live, shared file. This would allow the participants to already be familiar with the data and the models that use the data before they arrived at the workshop.

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5. NEXT STEPS

Near-term actions following the TIM address TTB processes for access and data collection. After the final plenary session, Doug Craig met with members of the ATLAS team and the ASCT leadership team to discuss the TIM and formulate near-term plans, including identifying NASA technologists to participate in the data collection process, defining data requirements for contracts, and documenting a procedure for establishing accounts in the web-based TTB. A process was laid out and actions assigned.

Headquarters will identify NASA technologists who will in turn identify other NASA technologists within their area of expertise. Technologists working on an ESRT contract will receive requirements to provide data for the TTB. The ATLAS development team will establish a process for creating accounts on the web-based version of the TTB. After establishing TTB accounts for the technologists, the ATLAS team will conduct interviews with each technologist and provide documentation on the fields of the TTB database. Through these interviews, the ATLAS team will collect the technology data and invite the technologists to review the data in the TTB. The data collection and vetting process will incorporate many of the recommendations from the TIM reflected in this report. Agendas for future TTB TIMs will facilitate discussions between the ATLAS system model developers and the community of technologists so that each group will understand the needs of the other.

In 2005, the ATLAS development team will conduct a data collection and vetting process for the TTB, develop system models for the ATLAS library, and produce documentation that explains these processes. If authorized to proceed into Phase II in 2006 and beyond, the ATLAS team will conduct a number of training workshops to recruit system model developers and technologists to populate the TTB. Each year, the ATLAS team will host two TTB TIMs to facilitate communication between the modeling and technology communities. Figure 7 depicts the spiral development process of ATLAS and the recurring TTB TIMs.
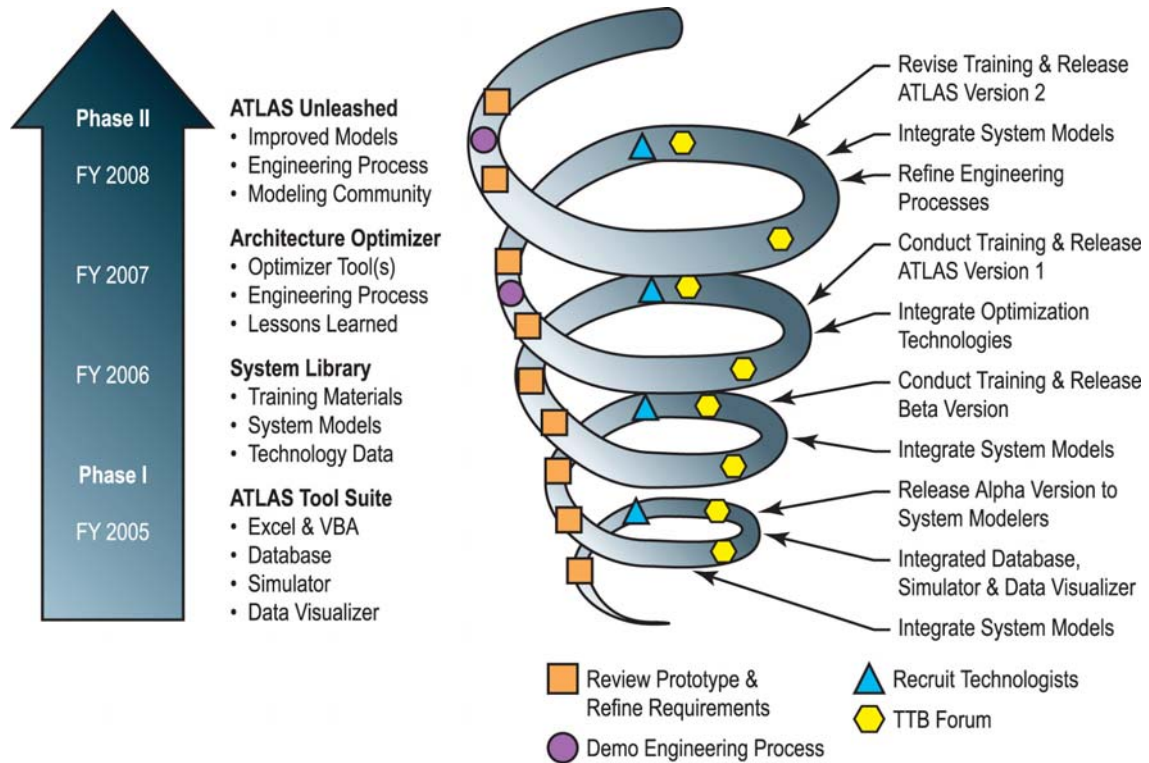
Figure 7 Spiral development lifecycle for ATLAS

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APPENDIX A—ATTENDEE LIST

First Name	Last Name	Affiliation	Working Group
Craig	Allsop	Northrop Grumman	Architecture & System
Arthur	Bradley	NASA LaRC	Tech Data Development
Steve	Cavanaugh	NASA LaRC	Definitions & Interface
Carissa	Christensen	The Tauri Group	Architecture & System
Al	Conde	NASA JSC	Tech Data Development
Doug	Craig	NASA HQ	Definitions & Interface
Jimi	Crawford	NASA ARC	Tech Data Development
Ramona	Cummings	NASA MSFC	Architecture & System
Daniel	Dean	Schafer	Architecture & System
LaMonte	Dent	UAH	Tech Data Development
Ravi	Deo	Northrop Grumman	Definitions & Interface
Monica	Doyle	SAIC	Tech Data Development
Jeff	Elbel	SAIC	Tech Data Development
Jaime	Esper	NASA GSFC	Tech Data Development
Jay	Falker	NASA HQ	Definitions & Interface
Harvey	Feingold	SAIC	Architecture & System
Kathy	Gavitt	Northrop Grumman	Tech Data Development
Gene	Rogers	Boeing	Tech Data Development
Mark	Gerry	NASA MSFC	Architecture & System
Wayne	Goode	SAIC	Architecture & System
Elaine	Gresham	The Tauri Group	Tech Data Development
Anthony	Gross	NASA ARC	Architecture & System
Steve	Hoffman	NASA SAIC	Architecture & System
Emily	Horton	The Tauri Group	Definitions & Interface
Hobson	Lane	Northrop Grumman	Tech Data Development
James L.	Lewis	NASA JSC	Architecture & System
Darby	Magruder	NASA JSC	Tech Data Development
Carie	Mullins	The Tauri Group	Tech Data Development
Daniel	O'Neil	NASA MSFC	Definitions & Interface
David	O'Neil	QTEC	Tech Data Development
Steve	Patrick	Sverdrup	Architecture & System
David	Reeves	NASA LaRC	Architecture & System
Bill	Sampson	Raytheon	Architecture & System
Jim	Sanders	ISSI	Tech Data Development
Mark	Shirley	NASA ARC	Definitions & Interface
Steven	Skonieczny	ISSI	Tech Data Development and Architectures & System
David	Smitherman	NASA MSFC	Tech Data Development
Jim	Thomas	ISSI	Tech Data Development
Pat	Troutman	NASA LaRC	Definitions & Interface
Jeremy	Vander Kam	NASA ARC	Definitions & Interface
Tim	Sarver-Verhey	NASA GRC	Tech Data Development
Clara	Welch	NASA MSFC	Architecture & System

**Technology Data Development & Collection
Working Group**

Tuesday November 9th

Chairs: Jaime Esper & Monica Doyle
Rapporteurs: Elaine Gresham and Carie Mullins

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Charge to the Working Groups:
Technology Data Development & Collection

- **Original Objectives:**
  – Review & come to consensus on data from group participants
    • Operating assumptions need to be refined prior to reaching a consensus
    • Developed operating assumptions that will form the basis for this consensus
  – Define growth scenarios for selected data set
    • Also dependent on operating assumptions
  – Identify person/source to complete blank fields
    • Done for many WBS elements, expecting additional inputs
  – Develop completion plan for marginal data sets, with likely assignments
    • To be tasked by respective technology leads
- **Products**
  – Completed data sets, with growth figures - TBD
  – Assignment list for follow-up data for workshop participants – see above
  – Sources for continuing data collection
    • Have identified potential sources for future data collection
    • Who will fund this?
  – Working group out brief

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Participants

- **Participants:**

| Jaime Esper (Chair)	NASA GSFC
Monica Doyle (Chair)	SAIC
Carie Mullins	The Tauri Group
Elaine Gresham	The Tauri Group
Steven Skonieczny	ISSI
Jim Sanders	ISSI
Jim Thomas	ISSI
Tim Sarver-Verhey	NASA GRC
James Crawford	NASA ARC
Al Conde	NASA SSC
Darby Magruder	NASA JSC
Arthur Bradley	NASA LARC
Kathy Gavitt	NGC
Hobson Lane	NGC
Gene Rogers	Boeing
Jeff Elbel	SAIC
David O'Neil	QTEC
David Smitherman	NASA MSFC
LaMonte Dent	UAH
Don Perkinson	Sverdrup

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Accomplishments

- **Total number of technology options where data was added**
  - Collected 27 data sets covering 16 Level 3 WBS areas
- **Identified data collection working group members**
- **Discussed methods for improving data collection and validation**
- **Specific WBS areas addressed:**
  - 2.2.1 Solar power generation
  - 2.6.1 Earth-to-orbit transportation
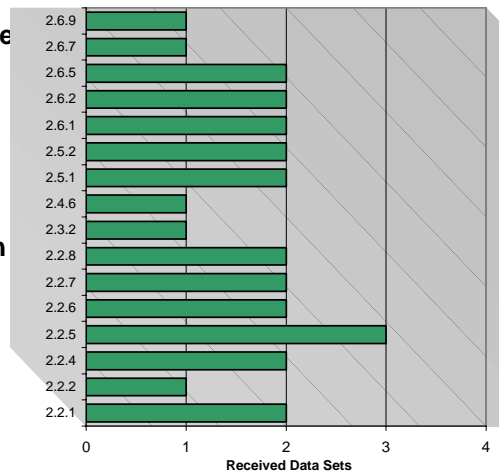
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Data Collection Recommendations

- **Conflicting data areas**
  - Not all data sets received have been examined in any detail
  - Identified complimentary data sets based on differing operating assumptions
- **Recommendations for future data collection**
  - Better define ground rules and assumptions regarding technology needs, context for metrics.
  - Vet existing data through independent reviewers
  - Bring "Fresh Blood" to the technology workshops, but maintain core participation
  - Bring more users and modelers to review for more integrated discussions.
- **Lack of proprietary data constrains the utility of the database.**
- **ITAR restrictions require password protection which limits users and impedes international participation**
  - this will be an issue if/when the TTB becomes a broader database, i.e. beyond the scope of the ATLAS model

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Operating Assumptions

- **Lack of systems engineering requirements definition necessitates development of constraints and operating assumptions by technologists.**
  - Initial inputs resulted in inconsistent data sets which were split into multiple records.
- **Define a set of operating assumptions that will allow technologists to provide consistent data**
  - Operating assumptions are technology-dependent and should be defined for each Level 3 WBS (possibly at a lower level).
  - A set of simplifying assumptions (for 1st cut) include:
    - BOL performance numbers for all technologies
    - Environment (1 AU)
    - Vacuum (GEO environment); Atmospheric (Mars or Earth)
    - What ancillary technologies are included (if any), ex: deployment mechanisms, etc.
- **Some technology records will be defined by technologies + configuration. Examples:**
  - flexible vs rigid Single Crystal MBG arrays are separate technology options
  - Need to provide precise definitions of the tech options, the assumptions and the data collection process prior to asking for data estimates.

Data Collection Process

- **For an efficient data collection process, we need to…**
    - Define the technology options very specifically
    - Create an ongoing group of technologists that are updated on the TTB progress and that will keep the TTB updated with changes in technologies
    - Identify subject matter experts to assign to the TTB (level 3 areas) to coordinate assumptions, and data collection
    - Define the assumptions by technology
    - Future participation and contributors
        - Users of ATLAS participate in data collection working group (users and modelers and program managers)
        - Work with NASA cross-center working groups (for example low-thrust high ISP)
        - Cross-industry working groups possibly the AIAA technical committees to provide contacts
        - Define the scope of work that is needed from contractors and NASA to allow them to plan future participation
- **If multiple, disparate data sets are received and cannot be reconciled, we should retain all data sets as separate records.**
    - This is ok as a first cut since we may not get multiple data sets.
    - As # of data sets increases, we may need to define data ranges.

Propulsion Data Collection

- **Propulsion Data Collection – specific issues**
    - ETO is chemical propulsion only
    - In space propulsion includes a range of technologies (chemical, electric, NEP, nuclear thermal, etc.)
    - Difficult/impossible to fill in data for advanced engines when mission requirements are not defined.
        - there would be arbitrary-ness involved if technologists are asked to provide data for advanced propulsion concepts.
        - may need to be more application dependent
        - need to know vehicle, power source, thrust req, etc.
    - Develop a set of case scenarios to define a number of point designs for the TTB
    - TRL 6 needs to be reached 6 years prior to use – assuming we start today, the earliest this database can be valid for propulsion is the 2014 time frame
    - Landing propulsion system driver of in-space propulsion development (2.6.3 could add information in about specific landing technologies)

Goal & Threshold Values

- **How do we define "Goal" and "Threshold" metric values?**
  - Option 1: replace these designations with "mean" and "deviation" of the probability distribution function
    - as a 1st cut, we can assume a normal distribution throughout. Note that distributions are not yet implemented.
  - Option 2: replace these designations with "Min" and "Max" and use these values to bound the data received.
    - Issue: Given multiple data sets for the same technology, storing Min value and Max value of each of each metric in the Min and Max columns, resp., may result in a data set that's not physically realizable.

- **For Timeframe 0 (state-of-the-art, FY05),**
  - A single value should be recorded (Goal=Threshold)
  - If multiple data sets are received for a single technology, try to reconcile any discrepancies.
  - If these cannot be reconciled, select the "best" technology.

Technology Readiness Level

- **TRLs should not decrease within a record**
  - if technology improvement results in a drop in TRL, a new technology record should be created. This new technology record begins at the point at which the TRL decreased.
  - TRLs can stay the same or increase for a given technology

- **TRL progression path(s) needs to be determined before technologists can provide data projections**
  - Technology maturation path: Technology performance metrics may stop improving while the maturity is advanced to TRL 6.
  - Pure Research Path: Technology performance improves while TRL may not increase. Technology may remain at breadboard level.
  - Should we include both and use these to interpolate?
  - Can Spirals be used to assign TRLs of 6 or higher? These may determine when some technologies need to be at TRL 6.

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**Architectures and Systems
Working Group**

Tuesday November 9th

**Chair: Harvey Feingold
Rapporteurs: Carissa Christensen**

**Charge to the Working Groups:
Architectures and Systems**

- **Objectives**
  - Define what is needed for modeling and analysis
  - Discuss existing and planned models, and technology data used
  - Discuss important technical data that should be included in models
  - Discuss architecture analysis for TTB, ATLAS, and SBA
  - Identify strategies for integrated use of TTB
- **Products**
  - Working group out brief
  - System to technology mapping

Participants

- **Clara Welch**
- **Carissa Christensen**
- **Bill Sampson**
- **David Reeves**
- **Daniel Dean**
- **Steve Patrick**
- **Steve Hoffman**
- **James Lewis**
- **Mark Gerry**
- **Ramona Cummings**
- **Craig Allsop**
- **Tony Gross**
- **Steve Skonieczuys**
- **Harvey Feingold**
- **Wayne Goode**

Accomplishments

- **Findings**
  - Context
  - Users
  - Functions
  - Optimization
- **Recommendations**
  - Future Model Development Management
  - Documentation
  - Maintenance
  - Management
  - Validation
  - Process

Findings

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Context

- **ATLAS = 'quick look' assessment of what makes sense**
  - Compare technologies, identify useful technologies
  - Top-level architectural trade studies
  - "Living forecast" of long-term missions/plans, enabling consideration of technology insertion of changing technologies
- **Trades**
  - ATLAS (top level)
  - Other models and analyses (detailed)
- **Engineering modeling (TTB should be fed by this level, but ATLAS is not appropriate for detailed engineering analysis)**

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Function of ATLAS

- **Determine if there is a long-term technology payoff**
- **Not an engineering design tool – but, what is expectation of ATLAS as part of SBA**
- **Point of model is not to analyze systems or design missions; purpose is to compare different technologies on mission strategies or campaign strategies**
  - Will this statement always be made? Will model continue to be used correctly?
- **Who are the users?**
  - John Mankins originally was target user; changing (growing) user population
  - Knowledge of user; need for documentation, user friendliness, error checking – GIGO could be damaging
- **How will it be used?**
  - Modelers
  - Technologists, independent of modeling

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Users

- **Who should ATLAS be designed for?**
  - Managers and planners
    - Headquarters program managers
    - Strategic planners
    - Program planners
  - Engineers, technologists, mission designers
  - Students (student version as a heuristic tool?)
  - Input to SBA
    - ATLAS funding for technologies
    - Input into requirements development
      - Pick best technologies
      - Prototyping
      - Deployment
    - TTB may feed whole life cycle of SBA
- **Who else might use ATLAS results?**
  - Budget analysts
  - External stakeholders (OMB, Congress)
  - Contractors
  - Academic community – curriculum, grants, studies
- **TTB may be the most useful element of ATLAS for a broad base of users**

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Optimization

- **Planned as part of future development**
- **Automated, smart optimization**
- **Figures of merit**
  - Cost
  - Mass
  - Safety, risk
- **Vary**
  - Technology
  - Systems
  - Architectures

SBA Relationship to ATLAS

- **Data dictionary/ontology for technology across databases**
- **SBA**
- **Engineering analysis environment**
- **Support strategy to task activity; traceability from top objectives to specific technology**
- **Model different architectures to do sensitivity analyses on different capabilities**
- **Enable CE&R contractors to run their models in the environment**
- **Contractors respond to RFPs with models in correct format**
- **Who is doing what level of analysis?**
  - SBA is lower level; ATLAS is higher level strategic analysis
- **SBA will have a 'point of departure' model – baseline to judge others against**
- **Requirements group will develop 1, 'we' will develop another; range of results**
- **CER models will in formats that can use ATLAS – esp TTB**
  - Plan is to translate SBA models into ATLAS compatible formats
  - Competition sensitive technology information
  - Models into right format
  - SBA has a risk tool – can that be plugged into ATLAS?
- **Data validation scale (estimate vs test results)**
- **Validation of ATLAS model through use of SBA to evaluate proposed systems as part of acquisitions**
- **Users**
  - Campaign assessment
  - SBA modelers

Recommendations

Future Model Development:
Enhancement of Existing Models

- **Current models already include (though not comprehensively):**
  - Propulsion
  - SPG
  - PMAD
  - In-space energy storage
  - Why included?
    - Modelers viewed as relevant
    - Data available in TTB
  - These models have many gaps in technologies that are included
    - Step 1 is to scrub these models to ensure that they have the most significant technology drivers in them
    - Revise models
- **Models do not include many other technologies that affect mass, such as…**
  - Materials properties

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**Future Model Development:
Include Technologies Affecting Reliability, Safety, Cost**

- **There are technologies the models do not reflect, even in some cases where there is data in the TTB**
  - Affect reliability, safety
  - These don't significantly affect mass but do affect cost
- **Software examples**
  - Planners and schedulers
  - System health management
  - Human assist technologies to aid astronauts, ground operators (advisory systems, long-term monitoring, voice interface)
  - Intelligent support for automation and rover systems (can supply a high-level goal and system will decide how to achieve goal)
  - Data analysis and management tools (will affect mission ops by partially analyzing data from sensors and changing mission activities accordingly)
- **Autonomous flight management and operations**
  - Software and hardware
- **Processor power**
  - Cost driver (rad hardening)
- **Simulation and training of humans (esp for EVA)**
  - Technologies for simulation systems
  - Technologies for training (faster, better)
- **Crew safety**
  - Abort
  - Return to Earth
  - Human rating-related technologies, testing, etc
- **Other important information/capabilities for models**
  - Maintainability (esp self-maintainability)
    - Software maintainability
    - Hardware maintainability
  - Human factors (e.g. fatigue on long-term missions)

**Future Model Development:
Functionality**

- **Printout of inputs, outputs, and appropriate flags**
  - Summary of choices
  - Flag of what has been changed from one case to another
  - Flag that results include 'user defined' technology
  - Results always linked to key inputs
    - Reference model
    - Changes from reference
  - FLAG ANYTHING THAT IS DIFFERENT FROM APPROVED MODEL
  - Configuration control and security – approved version
- **Pilot users?**
  - Web-based meetings
  - Different points of view
- **Roadmaps?**
  - Number of models, status, content
  - Users
- **Need one graphic of ATLAS (in, out) (CEO chart)**
- **User defined results**
  - Charts and graphs
  - Sensitivity analyses Notification of TTB update to users with active models

Future Model Development:
New Model Topics

- **Operations models considering impacts of e.g. automation**
- **Surface operations**
- **Mars missions (artificial gravity, shielding)**
- **Lunar, Mars isru**

Future TTB Development

- **TTB TBD – more robust default for missing information**
- **Column in TTB for date, source**
- **TTB data**
    - TTB should show currency of data
    - Control of data
    - WBS easy to understand
    - SBA will require long-term data to support integrated analysis of systems and systems-of-systems; ATLAS will need to have a flexible architecture to bring in real-world elements
    - Reliability data?
        - Reliability trades against mass, eg; different reliabilities = different technologoies?
        - Gross assessment of reliability? (h,m,l)?
        - Note: reliability is associated with a mature technology

Documentation

- **Existing**
  - Model introduction page – model developer, dates, etc
  - Initial versions of guide and plan documents
    - User's guide
    - Model developer's guide
    - Test plan (ATLAS overall)
    - System model compendium (partial; system definition, description of model, constraints and applicability of model)
- **Planned**
  - Completion of guide and plan documents
- **Needed**
  - Documentation of algorithms
    - Documentation of algorithms and logic will be necessary for validation process
  - Separate documentation as well as embedded; provide these instructions in developer's guide; standardize documentation approach
  - Model functions
    - Print out technologies used (tech table)
    - Label different cases being compared
  - Case study introduction page in case study electronic file
  - Documentation – define common interfaces for inputs and outputs to enable compatibility with other models

Maintenance

- **Data**
- **Software**
- **Documentation maintenance**
- **Training/support**
- **Long-term support**
  - Implications of BAAs, new approach of Code T, connection to Simulation-Based Acquisition (SBA)

Configuration Control

- **Configuration control board (CCB)**
    - Models
    - Technology inputs
    - Process
    - Documentation

Validation:
How should we determine if models are acceptable?

- **Trusted models**
    - Experience
    - Reference to real-life situations
        - Apollo as case study for ATLAS
        - Company (Q-Tech) is retrieving data on Apollo, Shuttle, Skylab
    - Takes a long time to build confidence in complex models
    - Planned and frequent model check procedures
        - Core model
        - System model
- **Many of ATLAS models are based on concepts that do not exist; can't test based on known values**
    - Experience with models, modelers, modeling approach
    - Sanity check/peer review
    - Existing model development community is fairly closed
- **Validate ATLAS with detailed design studies?**
    - ATLAS results for a mission compared to a detailed design study
    - What is a good design study?
    - Validation vs correlation
- **What is "good enough"?**
    - Not a detailed design tool; shouldn't be expected to come up with the same answers as a detailed design tool
    - Needs to produce RELATIVE answers among a few choices; does not need to produce ABSOLUTE answers

Validation:
Trusted Model Seal of Approval

- **Who determines?**
  - Review board
  - Independent
  - Ad hoc for each model
  - Informal in that model could be sent to individuals; who would answer specific set of questions; quick top-level look
  - Criticisms/response
  - Final approval or disapproval by ?
- **What is process?**
  - Algorithms
  - Input, output
  - Compliance with ATLAS requirements
  - NASA Independent Program Assessment Organization
    - Run from Langley
    - Experts from across field centers
    - Designed to be a quick investigation
    - Model by model? Overall program commitment?
    - Critical issue: how define process
  - Software validation and verification process within NASA? Is this a fit for ATLAS models?
  - Code T process owner
  - Documentation of algorithms and logic will be necessary for validation process
- **How indicated? "Seal of approval?" Excel add-in? logo provided?**
- **What criteria?**
  - Technology data current within defined period; technology data from TTB (which has some process for accepting data)
- **Specifies purpose of model**

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Caution
Documentation, Validation, Management

- **But…don't want to lose flexibility, speed**
  - How? HARD BOUNDARIES regarding how it is used
  - Keep models simple and quick
  - Versatility – easy to use, accessible

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Process

- **Results of previous workshops should be briefed at each workshop**
- **Share details of program plan**
- **On-going communication with community of interest**

**Database Definitions and Interfaces
Working Group**

Tuesday November 9th

**Chair: Doug Craig
Rapporteurs: Dan O'Neil
Emily Horton**

Charge to the Working Groups: Definitions and Interfaces

- **Objectives**
  - Develop analysis plan for ESR&T
  - Asses possibility for use of TTB by other tools
  - Asses possibility for use of ATLAS by other tools
  - Tools workshop pre-planning
- **Products**
  - Working group out brief
  - Draft analysis plan for ESR&T

Participants

- **Participants**
  - Doug Craig
  - Steve Cavanaugh
  - Jay Falker
  - Pat Troutman
  - Mark Shirley
  - Jeremy Vander Kam
  - Ravi Deo
  - Emily Horton

Definitions

- **Architecture –** A collection of systems that provide the capability to perform one or more types of missions
- **Campaign Analysis** – Evaluates the benefits across a sequence of missions and systems. Investigates the sensitivities of campaigns to technology portfolios.
  - **Supports the ASCT Advanced Study teams**
  - **Answers action items received by the ESR&T programs**
  - **Annual technology assessment and investment process**
  - **Verifies and validates technology data.**
- **Point-of-Departure (PoD) Architectures** – Produced by NASA and the Concept Exploration and Refinements (CE&R) Teams as a reference for benefit assessments.
- **Ontology** – An organizational structure for data including the technology data.
- **Threshold value** – The minimum achievable value within a range of a technology parameter.

Tools workshop pre-planning

- **Advanced Concepts**
  - Pat Troutman document process and products.
- **Technology Database(s)**
  - Jeremy Vander Kam and Dan O'Neil document process
- **Campaign Analysis**
  - Dan O'Neil document ATLAS output charts and provide to Steve Cavanaugh
- **Risk Analysis**
  - Jay Falker document the risk analysis activities and tool selection process.
- **Data Visualization**
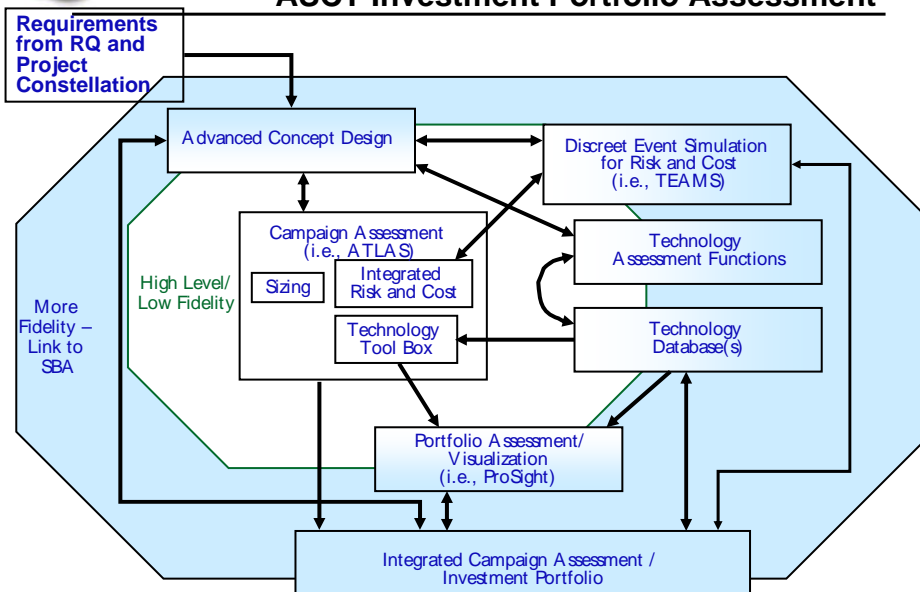 - Doug Craig document chart requirements in concert with SBA.

ASCT
ASCT Investment Portfolio Assessment

Analysis Plan

- **Data Requirements –** A verification & validation team within ASCT will define the requirements for the TTB data collection. These requirements will define the data pedigree.
- **Develop a centralized repository of technology data.**
  - Controlled access to the technology records
  - Record owners will provide the pedigree for record data values.
  - While data within records may not be subject to EAR/ITAR export control, the database as a whole must be controlled.
  - The database shall include data to support technology and system level risk analysis
  - A field in the database shall express the confidence in the data. Sometimes, degree of uncertainty becomes more important than the data.
  - An export function shall provide the capability to extract a subset of the database.
- **Data Migration Path**
  - In the near term, Excel and MySQL will instantiate the ATLAS TTB.
  - The SBA team will produce a Windchill technology database.
  - Experiments conducted in May 2005 will evaluate the capability to transfer data between MySQL and Windchill.
- **Risk Tool –** Evaluate the Freddie Douglas Safety-of-Flight risk analysis tool. By February, ESR&T will decide on the risk analysis tool.

ASCT Draft FY2005 Milestones

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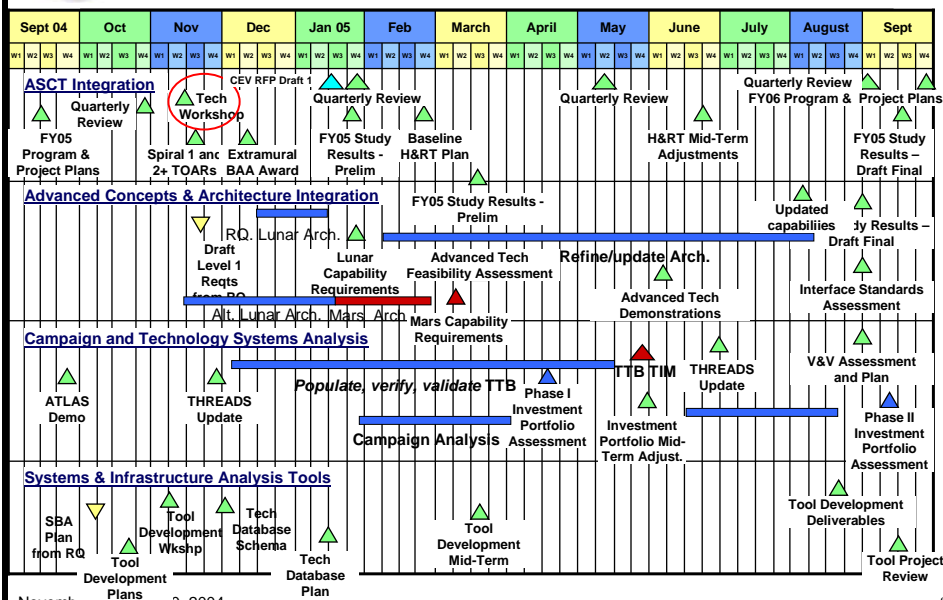
- Jimi Crawford manages a project to obtain operations data from United Space Alliance (USA). Establish a relationship between the ATLAS activity and this project

- Produce a list of technologists who will populate the Technology Tool Box (TTB) and own the records.

- Define working relationships between the ASCT technology database development team and technology working groups across the agency.

- The Simulation Based Acquisition (SBA) team and the ASCT campaign and technology analysis groups have overlapping charters.
  - Define the Level 0 and Level 1 analysis and associated tools.
  - Clearly define the roles and responsibilities of the two teams.

- The ASCT will be responsible for populating the technology database.

- **Operations Data Recommendation:** To get technology data from the contractors, the data requirements specified on the contractors must include data formats for the ESMD technology database.

- **Campaign Assessment Team** – A team will use ATLAS and other tools to analyze the architectures and associated missions. They provide comments to the Advanced Studies Teams and investment recommendations to the ESR&T management.

- **Technology assessments** – The technologists determine the state-of-the-art and forecasted metrics and enter the data into the technology database.
  - A team will perform sensitivity analysis at the system and technology level
  - Sensitivity analysis must be performed across many architectures and missions.

- **Format of technology roadmaps** should be consistent between ATLAS TTB and the Campaign Analysis data requirements.

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13. ABSTRACT *(Maximum 200 words)*

The objective of this Technical Interchange Meeting was to increase the quantity and quality of technical, cost, and programmatic data used to model the impact of investing in different technologies. The focus of this meeting was the Technology Tool Box (TTB), a database of performance, operations, and programmatic parameters provided by technologists and used by systems engineers. The TTB is the data repository used by a system of models known as the Advanced Technology Lifecycle Analysis System (ATLAS). This report describes the result of the November meeting, and also provides background information on ATLAS and the TTB.

14. SUBJECT TERMS

Technology Interchange Meeting (TIM), Advanced Technology Lifecycle Analysis System (ATLAS), Technology Tool Box (TTB), ATLAS TIM, ATLAS TTB

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